Province of British Columbia

Northwest Economic Development Studies

Mineral Resources

Ministry of Industry and
Small Business Development
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MINERAL RESOURCES REPORT

TASK FORCE ON NORTHWEST ECONOMIC DEVELOPMENT OPPORTUNITIES

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PREFACE

During late 1981 and early 1982 the Cabinet Committee on Economic Development made a series of fact-finding visits to Northwest British Columbia. In response to briefs presented by a large number of private citizens, corporations and public groups, the Cabinet Committee commissioned a report which would summarize the area's economic potential. That report "The Northwest Region, A British Columbia Regional Economic Study" was released on September 15th, 1982.

The September 1982 report states that the area north of the Highway 16/CNR northline corridor has substantial development potential based mainly upon the significant but largely undeveloped mineral resources. However, this area lacks virtually all of the necessary infrastructure to sustain early large scale development. Lack of transportation and municipal facilities and adequate power at reasonable cost are seen as significant constraints to development at the present time. The report noted that development of minerals and other resources will require substantial private and public investments - investments which can only be made after careful planning and consideration of alternatives.

In response to the September 1982 report, the Cabinet Committee on Economic Development directed an Inter-Ministry Task Force to begin work on a series of detailed studies on the northern part of the Northwest region (i.e. from Stewart to the Yukon border). These studies were undertaken to determine the scale and timing of potential mineral developments, and to identify options to supply power, transportation and community infrastructure in order to serve those developments. The Task Force was also asked to identify the social and environmental issues which might arise as development proceeds.

The product of these studies is a set of six Inter-Ministry Task Force reports plus a summary report which includes the findings of these six background studies. It should be emphasized that these studies do not represent a blueprint for development, but rather indicate priorities for future planning and development. The reports identify options and, as far as possible, the negative and positive factors associated with each option. Final decisions on any specific development options would be premature at this stage. Such decisions will have to await further analysis and more concrete private sector proposals for the development of the resources of the region.

Finally, it should be noted that during the course of these studies the mine development scenarios were refined as more information became available. These scenarios have been updated in the background reports where possible. However, in the power supply report and the transportation report, the analysis is based on the original hypothetical development scenario. The environmental overview report is based upon the early definitions of potential development options provided by the other working groups. The conclusions of these reports are not materially altered by the refined development scenario.

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Executive Summary

In early 1982, an interministry task force studied the economic development potential of Northwest British Columbia. The findings of this group were published in May 1982 ("Economic Development in Northwest British Columbia: Challenges and Opportunities"). The task force concluded that mining development would be the key growth sector in the northern part of the region. This report examines mining prospects in this area in more detail and projects possible development over the next two decades. After considerable pre-screening, nine major properties were selected for detailed evaluation from the list of known significant properties. Each of these nine properties appears capable of supporting a large scale mine in the region based upon presently known or inferred reserves.

Studies were undertaken to estimate, on a preliminary basis, the capital investment required to bring each property into production. Further studies estimated the operating cost for each potential mine/mill complex. Finally, a detailed evaluation of future market prospects was undertaken for the major minerals found in Northwest British Columbia. On this basis an optimistic and pessimistic range of prices was projected for selected years up to the year 2000. Given the estimated capital and operating costs for each mine/mill complex, and the projected mineral prices, the financial viability of each prospect at different time periods was analyzed.

This analysis indicates that Kutcho Creek and Klappan Coal are the prospects most likely to become viable mines towards the end of the 1980's or early in the 1990's. Stikine Copper is another interesting prospect, however, there are a number of technical problems relating to access and working conditions which are likely to delay development for a number of years. Schaft Creek appears to be a marginal prospect within the late 1980's or early 1990's time frame but could reach production by

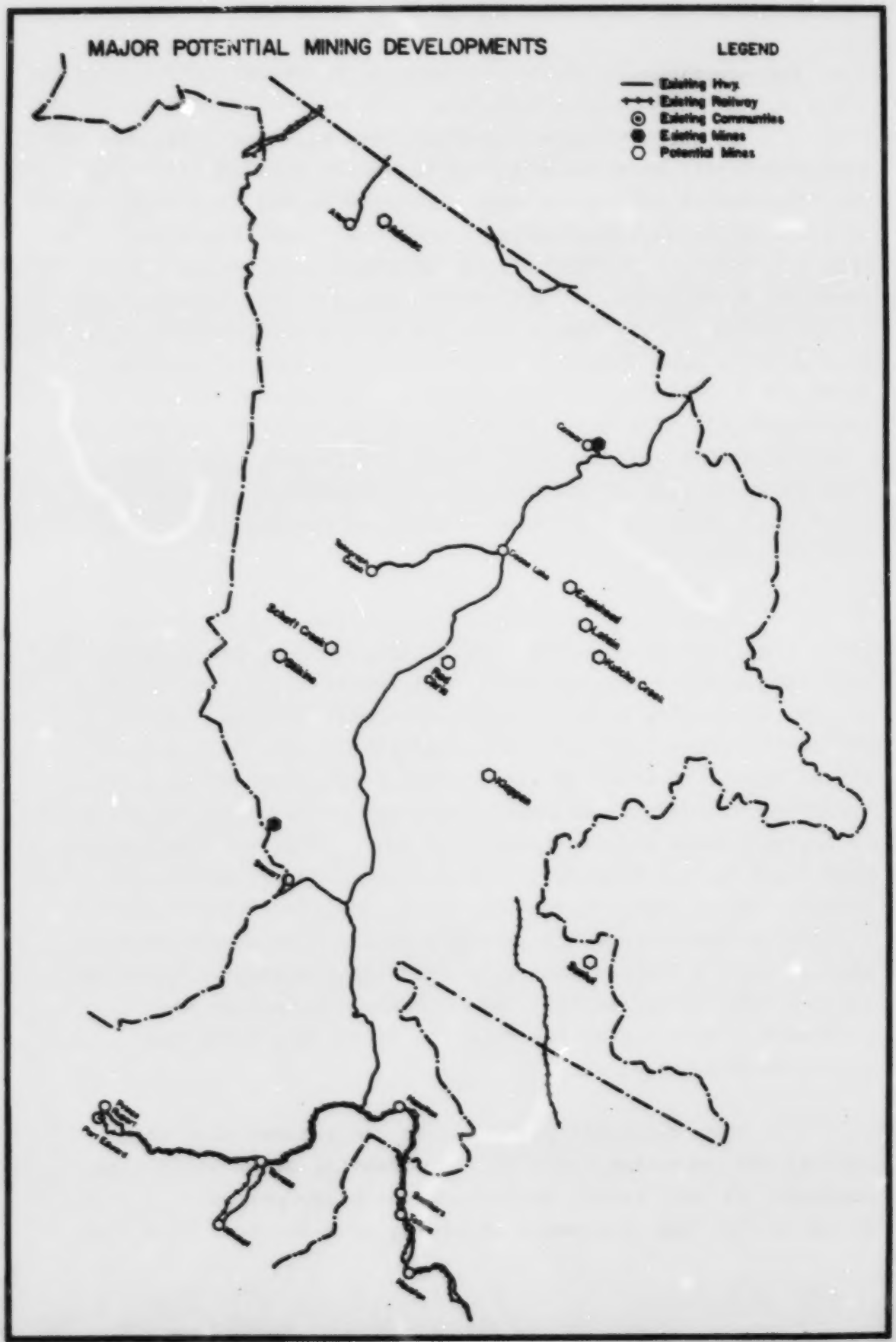
the year 2000. Eaglehead is also a marginal prospect; under optimistic assumptions it will reach production prior to the year 2000. Sustut Copper is very marginal and only under very optimistic assumptions will it reach production by the year 2000. Finally, Letain Asbestos, Adanac Molybdenum and Red Chris Copper appear unlikely to reach production prior to the year 2000, even from a very optimistic perspective.

1.0 Introduction

In early 1982, an interministry task force studied the economic development potential of Northwest British Columbia. The findings of this group were published in May 1982 ("Economic Development in Northwest British Columbia: Challenges and Opportunities"). The task force concluded that mining development would be the key growth sector in the northern part of the region. This report examines mining prospects in this area in more detail and projects the timing of possible development over the next two decades. After considerable pre-screening, nine major properties were selected for detailed evaluation from the list of 23 known significant properties. Each of these nine properties appeared capable of supporting a large scale mine in the region based upon presently known or inferred reserves.

Studies were undertaken to estimate, on a preliminary basis, the capital investment required to bring each property into production. Further studies estimated the operating cost per ton of ore for each potential mine/mill complex. For eight of the properties this work was performed, under contract, by Wright Engineers Ltd. Preliminary geological and other physical information regarding the ore bodies was provided by the Ministry of Energy, Mines and Petroleum Resources. This information was then input to existing Wright Engineers computerized costing models. These detailed cost estimates are presented in Appendix 1. For the ninth property (KLAPPAN COAL), some operating and capital cost estimates were received from the project developer (Gulf Canada Resources Ltd.) while other information was generated internally by the Ministry of Energy, Mines and Petroleum Resources.

For analytical purposes, it was assumed that the capital and operating costs of the potential mines would remain constant, in real terms, throughout the study period. Historically, the real costs of mining have declined over time


MAJOR POTENTIAL MINING DEVELOPMENTS
LEGEND
Existing Hwy.
Existing Railway
Existing Communities
Existing Mines
Potential Mines

due to technological advance. However, during the 1970's this trend reversed with real mining costs increasing quite dramatically over the decade. As a consequence, our assumption represents a compromise between these two trends.

Given the capital and operating costs of each mine/mill complex, a key factor determining the potential return on investment is the prices received for the minerals produced. Appendix 2 contains a detailed evaluation of future market prospects for the major minerals in Northwest British Columbia. On the basis of this analysis, optimistic and pessimistic prices are projected for selected years up to the year 2000. These prices are converted to Canadian dollars and summarized in Tables 1A and 1B.

Projected volumes, prices and the capital and operating cost estimates were input to the Ministry of Energy, Mines and Petroleum Resources mining financial analysis models (MINSIM and COALMOD). On the basis of the current taxation system and assumed transportation, smelting and refining costs, these models calculate net discounted cash flows, rate of return on investment over the life of the project, and payback period. All of these statistics are basic indicators of the potential viability of the mining projects.

A list of assumptions regarding each mineral property is presented in table 2 following. Conclusions regarding the viability of each mine under optimistic and pessimistic assumptions and at different dates are summarized in Section 2.

2.0 Project Viability

A mining prospect is considered to be financially viable in this study if, with the underlying assumptions, the discounted cash flow rate of return after tax is 15 percent or greater. MINSIM and COALMOD, like other financial analysis models, provide financial simulation of mining projects in a time neutral fashion. The model indicates whether, and not when, the prospect is a profitable proposition. In our analysis, the timing is determined by when mineral prices reach a sufficiently high level to generate an acceptable return. Given the difficulties in precisely forecasting world mineral prices and the costs of transporting, smelting and refining the commodities over an extended period of time, all projects were studied under an optimistic and pessimistic scenario. Under the optimistic scenario, the high prices outlined in table 1A were input to the model less a 15 percent allowance for transportation, smelting and refining charges. Under the pessimistic scenario, the low prices outlined in table 1B were input to the model less a 25 percent allowance for transportation, smelting and refining charges. The allowances for transportation, smelting and refining are developed from information provided by the Northwest Transportation Working Group and historical data published by the Mining Association.

Before discussion of the financial simulation results, certain other assumptions which are common to all prospects should be outlined.

First, the estimates of total capital and operating costs by Wright Engineers Ltd. are accurate to within a $\pm$20 percent range. Infrastructure costs for transportation, power and municipal infrastructure were largely but not totally included in these estimates. For example, possible upgrading of highway number 37 was excluded, but all necessary access roads to the mine-sites from the highway 37 corridor were included. Similarly, corporate investment for employee housing is included but other necessary elements of municipal infrastructure were excluded.

Table 1A

Optimistic Price Forecasts by Mineral

(1982) Canadian $)*

Year	Copper/kg	Molybdenum/kg	Zinc/kg	Asbestos/tonne	Silver/troy ounce	Gold/troy ounce	Anthracite coal/tonne
1982	1.81	12.34	.86	877	9.21	466.00	97.00-194.00
1985	3.42	10.14	1.52	600**	11.50	862.50	115.00
1990	4.32	12.67	1.77	700**	17.25	862.50	132.00
2000	5.58	15.20	2.03	800**	28.75	862.50	172.00

Table 1B

Pessimistic Price Forecasts by Mineral

(1982 Canadian $)

Year	Copper/kg	Molybdenum/kg	Zinc/kg	Asbestos/tonne	Silver/troy oun e	Gold/troy ounce	Anthracite coal/tonne
1985	3.04	10.14	1.14	450*	11.50	287.50	97.75
1990	3.55	11.41	1.39	450*	11.50	287.50	97.75
2000	3.80	11.41	1.52	450*	11.50	287.50	97.75

* Assumes exchange rate of $1.15 Canadian/U.S.$
** Net of transportation charges

TABLE 2

COMPARATIVE PROFILE OF POTENTIAL MAJOR MINING DEVELOPMENTS

PROJECT NAME	MINE TYPE	PRODUCTS	MILLING RATE tonnes/day	LIFE OF MINE (years)	CONCENTRATE OUTPUT tonnes/year	TOTAL CAPITAL COST $ (million)	OPERATING COST/TONNE MILLED
Kutcho Creek	Open Pit & Underground	Copper Zinc Silver	4,265	11.0	138,000	277	25.63
Eaglehead	Open Pit	Copper Molybdenum Silver Gold	9,100	15.0	39,000	213	10.50
Letain	Open Pit	Asbestos	2,000	15.0	24,000	66	33.00
Adanac	Open Pit	Molybdenum	14,000	31.0	5,000	233	7.61
Schaft Creek	Open Pit	Copper Molybdenum Silver Gold	91,000	25.0	318,000	1,095	4.46
Stikine	Open Pit	Copper Silver Gold	27,216	14	303,000	746.3	7.84
Sustut	Open Pit	Copper	5,443	11	55,000	219.5	17.65
	or Underground		5,443	11	55,000	264.1	33.86
Red Chris	Open Pit	Copper Gold	4,100	29	24,000	143.7	17.08
Klappan	Open Pit	Anthracite Coal	14,300 2,800	20 20+	5,000,000 1,000,000	700.00 155.00	28.00 35.00

Second, the financial analysis assumes a continuation of existing taxation regimes at both federal and provincial levels including existing royalty and depreciation rules.

Finally, in all cases 100 percent equity financing was assumed to provide a consistent base for comparative financial analysis.

2.1 Kutcho Creek

Kutcho Creek is a copper and zinc prospect with very significant silver by-product values. The outlook for zinc is relatively promising over the next two decades and is a favourable factor influencing this prospect.

With pessimistic 1990 assumptions, the Kutcho Creek property generates an after tax return on investment of around 15 percent. Assuming that a 15 percent expected rate of return after tax is necessary to bring the prospect into production, on a pessimistic basis Kutcho Creek is a marginal prospect in 1990. Using optimistic 1990 assumptions, the Kutcho Creek property generates an after tax return on investment well in excess of 15 percent. Optimistically, it seems likely that Kutcho Creek will proceed considerably before 1990. Based on these results, development of Kutcho Creek appears likely in the late 1980's or early 1990's.

2.2 Eaglehead

Eaglehead is a medium size copper/molybdenum prospect with minor precious metal by-product potential. As a consequence, development of this project is almost entirely dependent on trends in the copper market.

With pessimistic 1990 assumptions, the Eaglehead property generates a loss on investment. With optimistic 1990

assumptions, the prospect generates an after tax return on investment of around 15 percent. Using pessimistic year 2000 assumptions, the after tax return on Eaglehead falls well below 10 percent. Using optimistic year 2000 assumptions, the after tax rate of return reaches well in excess of 15 percent. Assuming that a 15 percent expected rate of return is necessary prior to the prospect reaching production, optimistically Eaglehead will produce in the mid to late 1990's. Pessimistically, however, production could be delayed well beyond the year 2000.

2.3 Letain

Letain is a potential asbestos mine. However, the ore grade here is lower and the fibre length is shorter than at Cassiar. The net result is a less valuable product. Also, future market prospects for asbestos are uncertain due to environmental and health concerns.

With optimistic 1990 assumptions, the Letain asbestos prospect generates a loss on investment. Even with optimistic year 2000 assumptions, this situation is unaltered. It is therefore unlikely that this prospect will reach production prior to the year 2000. However, it should be noted that the price projections here are particularly weak. Unlike most base and precious metals, asbestos prices vary widely with product quality. This is an additional element of uncertainty with the analysis.

2.4 Adanac

Adanac is a large molybdenum deposit near Atlin which was very near a production decision in 1980. Unfortunately, the market for molybdenum has deteriorated very substantially and the future market prospects are now universally gloomy over the next 20 years.

Using optimistic 1990 assumptions, the Adanac molybdenum prospect generates a loss on investment. Even using

optimistic year 2000 assumptions this situation is unaltered. It is unlikely that this prospect will reach production prior to the year 2000.

2.5 Schaft Creek

Schaft Creek is a very large, low grade copper/ molybdenum deposit and could support a mine as large as the existing Lornex mine in the Highland Valley. The precious metal by-product potential of this deposit is relatively low and, as already noted, the outlook for the molybdenum market is very pessimistic over the next 20 years. Like Eaglehead, the timing of development is almost entirely dependent on trends in the copper market. The outlook here is mixed. All analysts agree that prices will rise from their current cyclical lows, but how far is subject to a considerable debate.

With pessimistic 1990 assumptions, the Schaft Creek copper prospect generates an after tax return on investment well below 15 percent. With optimistic 1990 assumptions, the Schaft Creek property generates an after tax return on investment slightly above 15 percent . Since it is assumed that a 15 percent expected rate of return is necessary prior to the prospect reaching production, optimistically Schaft Creek could be on the verge of producing in 1990.

However, using pessimistic year 2000 assumptions, the after tax rate of return on Schaft Creek falls below 15 percent. Pessimistically, the development of this prospect may be delayed until after the year 2000. The scale of production and investment with this prospect is such that profitability is strongly influenced by relatively minor changes in product prices.

2.6 Stikine

Stikine is a deposit of high grade (in excess of 1%) copper with very significant silver by-product values.

With pessimistic 1990 assumptions, the Stikine copper property generates an after tax return on investment of approximately 15 percent. Using optimistic 1990 assumptions, the Stikine property generates a rate of return well in excess of 15 percent. Assuming that a 15 percent expected rate of return is necessary prior to the prospect reaching production, Stikine copper may produce before 1990. Even pessimistically, the project should proceed by the year 2000.

Unfortunately, there are a number of technical problems which may substantially delay development. In particular, access to the resource is exceptionally difficult and may require major tunnelling. Also, the deposit is located near glaciers, implying very difficult working conditions.

2.7 Sustut

Sustut is a high grade copper deposit (in excess of 1%) but with no precious metal or other by-product potential.

Also, there is some question whether Sustut can be brought into production as an underground or an open pit mine. If an underground operation is necessary both capital and operating costs will be considerably higher than with open pit methods. However, even assuming a lower cost open pit operation is possible, and using optimistic year 2000 assumptions, the after tax return on investment barely reaches 15 percent. Assuming that a 15 percent expected rate of return after tax is necessary prior to the prospect reaching production, even optimistically Sustut is just marginal in the year 2000.

2.8 Red Chris

Red Chris is a relatively low grade (0.56%) copper deposit with low precious metal by-product potential. Also, the configuration of the ore body is such that it will seriously constrain the scale of operation. The resulting relatively high

unit operating costs require a very high copper price prior to a production decision.

With optimistic 1990 assumptions, the Red Chris property generates negligible returns on investment. Even with optimistic year 2000 assumptions, the Red Chris property generates an after tax return on investment well below 15 percent. Assuming that a 15 percent rate of return after tax is necessary prior to the project proceeding, Red Chris does not seem viable prior to the year 2000.

2.9 Mount Klappan Coal

In order to use recent information made available by the developer, Gulf Canada Resources Inc., a different procedure was used to evaluate the Mount Klappan Coal prospect. Two cases were evaluated representing the most recent concepts of the developer.

The first case is an operation producing 1 million tonnes of high value clean product coal with a 1982 selling price of Cdn. $150 c.i.f. in Europe. Transportation charges of Cdn. $31 were estimated on the basis of experience with Northeast coal. Total capital costs and their distribution were based on data from British Columbia coal projects and adjusted after discussions with Phillips Barratt Kaiser Engineers and Gulf Canada Resources Inc.

The second case is an operation which produces 5 million tonnes per year distributed as follows:

1 million tonnes of 5% ash product coal, C.I.F. price Europe Cdn. $150

2 million tonnes of 10% ash product coal, C.I.F. price Eastern Canada or Asia Cdn. $110

2 million tonnes of 25% ash product coal, C.I.F. price Korea Cdn. $80

The results show that based upon current 1982 market prices for anthracite coal, the Mount Klappan prospect is a viable mine under either production scenario. Unlike other prospects in the Northwest, the key constraint is the development of a market for the product rather than the current price of the product. As outlined in Appendix 2, the prospects for markets development in South Korea appear good by the late 1980s. However, the demand in Korea will be for low priced, high ash product coal. Penetration of the high price, low ash European market may take some time for a new Canadian product. Consequently, the development of this project could be delayed beyond the late 1980s if an adequate Asian market is not available.

3.0 Conclusions

Our analysis of the nine major mineral prospects in Northwest British Columbia indicates that Kutcho Creek and Klappan Coal are the prospects most likely to reach production by the late 1980's or early 1990's. Stikine copper, from a strict minehead value perspective also appears to be a promising prospect. However, technical problems may delay development of this mine for some time. Schaft Creek and Eaglehead appear to be marginal prospects within late 1980's or early 1990's time frame but they could reach production by the year 2000. Sustut Copper will reach production prior to the year 2000 only under very optimistic assumptions. Adanac Molybdenum, Letain Asbestos, and Red Chris Copper are unlikely to reach production prior to the year 2000 even from a very optimistic perspective.

A number of qualifications should be attached to this analysis. First, assumptions used in the analysis regarding transportation, smelting and refining costs are highly aggregated and further refinement should be attempted. Second, the analysis has been performed under the assumption that the private sector absorbs many of the necessary infrastructure costs. Should the public sector absorb a percentage of such costs, then the financial viability of projects will be enhanced. This would be particularly true of the Schaft Creek project and it is therefore suggested that further sensitivity analysis may be warranted in this area.

Finally, the analysis has been performed given the present knowledge of the deposits. Further exploration activities may define greater ore reserves or improved ore grades which would substantially change the viability of the prospects by increasing projected revenues, increasing the scale of the operation or extending the mine life. For example, exploration work performed in 1982 by Falconbridge on the Windy Craggy prospect delineated substantially increased reserves of

copper and cobalt. This prospect was initially excluded from detailed analysis, but on the basis of this most recent information should probably be included. The results of future exploration activities are an important element of uncertainty overlying this analysis.

Appendix 1

Capital and Operating Cost Estimates
for Selected Potential Mine
Developments in Northwest British Columbia

* Wright Engineers estimates were generally developed and are reported here on a short ton capacity basis. In the main text, these figures were converted to metric measures.

Capital and operating costs for eight key Northwest mining prospects were estimated by Wright Engineers Limited. Preliminary geological and other physical information was provided by the Ministry of Energy, Mines and Petroleum Resources while the potential scale of each mine/mill complex was projected on the basis of similar ore bodies elsewhere. Using this information in computerized costing programs, Wright Engineers produced "order of magnitude" costs for each potential mine/mill complex. These estimates should not be confused with detailed cost estimates such as those developed for feasibility studies. The estimates provided here are adequate only for preliminary evaluation purposes. The estimated accuracy for individual cost areas is $\pm$ 30 percent while the total cost estimate is accurate to between $\pm$ 15 and 20 percent.

In all instances, Wright Engineers were requested to assume that power is supplied from small hydro facilities specifically developed for each mine/mill complex. To the extent that small hydro is not feasible and other higher cost alternatives are necessary, costs will be underestimated. On the other hand, to the extent that facilities can be shared or other lower cost alternatives are available, costs will be overestimated.

With respect to other possible shared facilities such as roads and townsites some subjective assumptions were made regarding the timing of various developments. For example, in the case of Kutcho Creek, Eaglehead and Letain Asbestos, Kutcho Creek was assumed to proceed first. As a result, Kutcho Creek bears the major costs of road access and employee housing in the region. Both Eaglehead and Letain benefit from the path breaking efforts of Kutcho Creek in the sense that access and employee housing costs are relatively low. Similarly, it is assumed that Schaft Creek precedes Stikine Copper and that town site facilities can be shared. It should be evident that the assignment of costs between developments in these instances is largely arbitrary.

Table 1

Capital Cost Estimate
Kutcho Creek Copper/Zinc*
Project

Assumed Capacity 4700 tons per day
(Millions 1982 Canadian Dollars)

	Open Pit	Underground	Total
Mine Development	$ 38.09	59.16	97.25
Site Development	2.81		2.81
Crushing	11.61		11.61
Processing	24.56		24.56
Water Supply	3.55		3.55
Tailing Disposal and Water Reclamation	4.23		4.23
Power Supply and Distribution (Hydro)	31.12		31.12
Ancillary Buildings	9.88		9.88
Access Road, Surface Vehicles and Fuel Storage	19.63		19.63
Employee Housing	22.71		22.71
SUB TOTAL	$168.20	59.16	227.35
Working Capital	17.66	6.21	23.87
Engineering and Field Supervision	14.13	4.97	19.10
Administration Costs	6.30	--	6.30
TOTAL CAPITAL COST	$206.29	70.34	276.63

* Kutcho Creek is a complex prospect as only part of the available reserves can be exploited through open pit methods. An underground mine will eventually be required.

Table 2

Operating Cost Estimates
Kutcho Creek Copper/Zinc
Project

Assumed Capacity = 4700 tons per day
(1982 Canadian Dollars per ton milled)

	Open Pit	Underground
A. Mining Cost	$ 4.96	12.53
B. Milling Cost	4.81	4.81
C. General Overheads	4.68	5.92
TOTAL COST	$14.45	23.26

Table 3

Capital Cost Estimate
Eaglehead Copper/Molybdenum
Project

Assumed Capacity 10,000 tons per day
(Millions 1982 Canadian Dollars)

Mine Development-Open Pit	$ 49.31
Site Development	3.63
Crushing	19.15
Processing	33.81
Water Supply	5.40
Tailing Disposal and Water Reclamation	5.09
Power Supply and Distribution (Hydro)	43.03
Ancillary Buildings	12.00
Access Road, Surface Vehicles and Fuel Storage	1.69
Employee Housing	2.92
SUB TOTAL	$ 176.04
Working Capital	16.72
Engineering and Field Supervision	13.38
Administration Costs	7.15
TOTAL CAPITAL COST	$ 213.29

Table 4

Operating Cost Estimate
Eaglehead Copper/Molybdenum
Project

Assumed Capacity 10,000 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 3.52
B.	Milling Cost	3.05
C.	General Overheads	2.93
	TOTAL	$ 9.50

Table 5

Capital Cost Estimates
Letain Asbestos
Project

Assumed Capacity 2,200 tons per day
(Millions 1982 Canadian Dollars)

Mine Development-Open Pit	$ 9.91
Site Development	1.75
Crushing	15.71
Processing	8.13
Water Supply	.45
Tailing Disposal and Water Reclamation	1.97
Power Supply and Distribution (Hydro)	6.74
Ancillary Buildings	5.54
Access Road, Surface Vehicles and Fuel Storage	1.42
Employee Housing	1.07
SUB TOTAL	$ 52.68
Working Capital	$ 5.01
Engineering and Field Supervision	4.43
Administration Costs	3.57
TOTAL CAPITAL COST	$ 65.68

Table 6

Operating Cost Estimates
Letain Asbestos
Project

Assumed Capacity 2,220 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 6.01
B.	Milling Cost	9.84
C.	General Overheads	14.06
	TOTAL COST	$ 29.91

Table 7

Capital Cost Estimate
Red Chris Copper
Project

Assumed Capacity 4,500 tons per day
(Millions of 1982 Canadian Dollars)

Mine Development-Open Pit	$ 17.33
Site Development	2.85
Crushing	12.85
Processing	20.62
Water Supply	3.21
Tailing Disposal and Water Reclamation	4.05
Power Supply and Distribution (Hydro)	25.48
Ancillary Buildings	8.13
Access Road, Surface Vehicles and Fuel Storage	1.77
Employee Housing	18.29
SUB TOTAL	$ 114.58
Working Capital	$ 12.03
Engineering and Field Supervision	10.59
Administration Costs	6.49
TOTAL CAPITAL COST	$ 143.69

Table 8

Operating Cost Estimate
Red Chris Copper
Project

Assumed Capacity 4,500 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 3.95
B.	Milling Cost	5.47
C.	General Overheads	6.08
	TOTAL COST	$ 15.50

Table 9

Capital Cost Estimate
Adanac Molybdenum
Project

Assumed Capacity 15,000 tons per day
(Millions 1982 Canadian Dollars)

Mine Development-Open Pit	$ 47.33
Site Development	4.03
Crushing	8.74
Processing	48.14
Water Supply	6.11
Tailing Disposal and Water Reclamation	6.96
Power Supply and Distribution (Hydro)	46.69
Ancillary Buildings	14.53
Access Road, Surface Vehicles and Fuel Storage	4.00
Employee Housing	3.56
SUB TOTAL	$ 190.08
Working Capital	$ 19.01
Engineering and Field Supervision	15.05
Administration Costs	9.14
TOTAL CAPITAL COST	$ 233.29

Table 10

Operating Cost Estimate
Adanac Molybdenum
Project

Assumed Capacity 15,000 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 2.23
B.	Milling Cost	2.43
C.	General Overheads	2.25
	TOTAL	$ 6.91

Table 11

Capital Cost Estimate
Schaft Creek Copper
Project

Assumed Capacity 100,000 tons per day
(Millions 1982 Canadian Dollars)

Mine Development-Open Pit	$ 147.06
Site Development	14.35
Crushing	25.84
Processing	212.30
Water Supply	29.60
Tailing Disposal and Water Reclamation	58.76
Power Supply and Distribution (Hydro)	243.10
Ancillary Buildings	39.13
Access Road, Surface Vehicles and Fuel Storage	22.20
Employee Housing	108.35
SUB TOTAL	$ 900.69
Working Capital	$ 90.07
Engineering and Field Supervision	71.33
Administration Costs	32.85
TOTAL CAPITAL COST	$1094.94

Table 12

Operating Cost Estimate
Schaft Creek Copper
Project

Assumed Capacity 100,000 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 1.23
B.	Milling Cost	1.73
C.	General Overheads	1.03
	TOTAL COST	$ 4.04

Table 13

Capital Cost Estimate
Stikine Copper
Project

Assumed Capacity 30,000 tons per day
(Millions 1982 Canadian Dollars)

Mine Development-Open Pit	$ 152.62
Site Development	11.02
Crushing	40.71
Processing	80.96
Water Supply	12.15
Tailing Disposal and Water Reclamation	12.32
Power Supply and Distribution (Hydro)	106.46
Ancillary Buildings	24.77
Access Road, Surface Vehicles and Fuel Storage	168.33
Employee Housing	7.50
SUB TOTAL	$ 616.84
Working Capital	$ 64.77
Engineering and Field Supervision	48.85
Administration Costs	15.84
TOTAL CAPITAL COST	$ 746.30

Table 14

Operating Cost Estimate
Stikine Copper
Project

Assumed Capacity 30,000 tons per day
(1982 Canadian Dollars per ton milled)

A.	Mining Cost	$ 2.98
B.	Milling Cost	2.28
C.	General Overheads	1.85
	TOTAL COST	$ 7.11

Table 15*

Capital Cost Estimates
Sustut Copper
Project

Assumed Capacity 6,000 tons per day
(Millions 1982 Canadian Dollars)

	Open Pit	Underground
Mine Development-Open Pit	$ 45.23	58.31
Site Development	2.59	2.59
Crushing	15.31	9.52
Processing	25.53	25.53
Water Supply	6.25	6.25
Tailing Disposal and Water Reclamation	4.22	4.22
Power Supply and Distribution (Hydro)	31.80	31.80
Ancillary Buildings	11.49	9.57
Access Road, Surface Vehicles and Fuel Storage	7.59	7.59
Employee Housing	27.62	59.49
SUB TOTAL	$177.62	214.86
Working Capital	18.65	22.56
Engineering and Field Supervision	15.63	18.91
Administration Costs	7.74	7.74
TOTAL CAPITAL COST	$219.64	$264.07

* It is uncertain whether open pit or underground methods will be required to exploit this deposit

Table 16

Operating Cost Estimates
Sustut Copper
Project

Assumed Capacity 6,000 tons per day
(1982 Dollars per ton milled)

	Open Pit	Underground
A. Mining Cost	$ 6.45	$ 15.82
B. Milling Cost	4.95	4.95
C. General Overheads	4.62	9.96
TOTAL COST	$ 16.02	$ 30.73

APPENDIX 2

MINERAL MARKET PROSPECTS TO THE YEAR 2000

1.0 Introduction

Over the long term, mineral prices are generally controlled by costs. As demand increases over time and currently producing mines reach exhaustion, prices must be adequate to cover the operating and investment costs of bringing new mines into production. Prices may fall substantially below this long run equilibrium in the short term. Since investment once made is a sunk cost, mines may continue to operate although substantial financial or economic losses are incurred. As long as revenues exceed operating costs, leaving some balance to offset fixed charges, the rational entrepreneur will continue to produce. However, in the long term, prices must rise from such cyclical lows if production is to be increased or even maintained.

Over time, scarcity tends to increase long run cost and prices as declining ore grades and less accessible resources must be brought into production. On the other hand, technological advance tends to offset the effects of scarcity by increasing the efficiency of capital and labour over time. The balance between these two influences is evident in the history of mineral prices. For example, with copper a long period of temporal decline in prices occurred from the late 19th century through to the 1930's as open pit mining became feasible with the application of modern metallurgical techniques. Since then prices have been on a temporal upswing as increasing scarcity became the dominant factor.

In this study, we tend to discount the influence of technology on the cost of extracting Northwest mineral resources. We assume that extraction costs will remain constant in real terms over time. For consistency, throughout this market analysis we are similarly pessimistic regarding the influence of technology on long run prices. Scarcity is assumed to be the sole determining factor of long run price trends. In this framework, the extent to which prices will rise depends upon

demand growth over time, and the relative abundance of the commodity in question. For each of the major minerals in the Northwest, these issues are examined in some detail in the following pages. In all instances we offer both an optimistic and pessimistic scenario regarding future prices. Detailed market projection over a twenty year period is inevitably imprecise. Even minor error in predicting key underlying variables can be magnified dramatically, and new potential uses of a material, or alternatively, substitutes for a material in current uses can only be vaguely foreseen. Also, the actual path of prices can be expected to cycle in response to short term influences such as the current recession. The range of prices is intended to reflect these uncertainties.

2.0 Copper

World refined copper consumption rose at an average annual rate of 4.6 percent between 1950 and 1979. There are clear indications, however, that growth in copper consumption has peaked and is on a temporal decline. Average annual consumption growth rate in the 1960's was 4.4 percent and this slowed to 3.1 percent in the 1970's. Copper useage in most of the major market economies has reached saturation and a general slowdown is expected in the future. Although there is still potential for dramatic growth in copper consumption in less developed nations, the present consumption share of these countries is quite small and they will not have a major impact prior to the turn of the century.

The major end use sectors for copper are, electricity, telecommunications, construction, machinery and transportation. Electricity and telecommunications are by far the most important representing, for example, more than 58 percent of total U.S. consumption in 1979. Copper has been the historically preferred material in power transmission lines, telephone lines and other cable uses. However, in both of these sectors, substitution of alternative products has had an impact and will have a further impact in the future. In the developed countries, aluminum has already substituted for copper in overhead power transmission cables due to its weight advantages. In the telecommunications field "fibre optics" which use glass fibres have the capacity to carry larger volumes of traffic than traditional copper cable. This technology is under rapid development and will undoubtedly see large scale application in the near future. Also, alternative transmission media including microwave towers, satellites and so on are reducing the need for cable. Theoretically, increasing use of telecommunications and electrification in less developed countries' offer a significant growth prospect for copper, but consumption growth is likely to be constrained below historic levels in these nations due to the factors mentioned above.

Residential construction is the next major user of copper accounting for about 18 percent of U.S. consumption in 1979. Copper is the preferred material for household branch circuit wire. An attempt was made in North America between the mid 1960's and 1970's to substitute aluminum in these systems, but this generally proved a failure. Safety problems related to fire incidents has strengthened the position of copper in this market. Copper is also the traditionally preferred material for household plumbing systems. Plastic tubing has made some in-roads here, but only in quite restricted uses. Of more significance to copper consumption is a tendency towards more efficient useage in the form of thinner walled and narrower bore pipe systems.

In the machinery sector, copper is well established as the material for valves, pipe fittings, bearings and pumps. In 1979, this represented approximately 9 percent of total U.S. consumption. This will likely remain an important field although substitutes such as stainless steel will continue to make in-roads.

The transportation sector is the last major consumer of copper with a combined useage in all modes of transport virtually equivalent to the machinery sector. In the automotive industry, copper is used in wiring and radiators. Studies have shown that the amount of copper used is highly correlated to automobile size ranging from as little as 15 lbs. in smaller automobile models to as much as 100 lbs. in a truck. As a result, copper is highly vulnerable to the recent down-sizing and weight saving efforts of auto manufacturers. For example, although recognized as inferior materials; aluminum and plastic are increasingly displacing copper in radiators due to their weight advantages. The railway industry is a relatively small consumer of copper but a trend towards electrification offers good growth prospects. In the ship-building industry, copper and its alloys will continue to be the preferred material in many uses.

Solar energy and water de-salinization are potentially growing fields for copper useage. In both areas, demand for copper will depend upon the direction of future research and development as well as the number of units eventually installed. Some of the systems currently available use relatively small amounts of copper while other systems are substantial users.

Table 1 following, lists a number of major copper consumption forecasts to the year 2000. Virtually all forecasts represent a considerable slow down from the high growth rates of the 1950's and 1960's. Also, all analysts agree that U.S. consumption growth will fall well below the world average. Apart from this, there is a considerable range of opinion regarding consumption growth rates. Resources for the Future predicts the lowest average growth rate at 2.7 percent per annum. At the other extreme, the U.S. Bureau of Mines optimistically predicts growth at 3.9 percent per annum. The resulting estimates of total refined copper consumption in the year 2000 range from 18 to 26 million short tons. This represents between a 67 and 141 percent increase in refined copper consumption over 1979.

TABLE 1
Long-Range Refined Copper Consumption Forecasts
(000 short tons)

	United States		Rest of World		World	
Forecast	Average Annual Growth Rate to 2000, %	Copper Consumption in 2000	Avg. Annual Growth Rate to 2000, %	Copper Consumption in 2000	Avg. Annual Growth Rate to 2000, %	Copper Consumption in 2000
U.S. Bureau of Mines	3.0	5,071	4.2	20,944	3.9	26,015
Malenbaum	1.9	3,530	3.0	15,032	2.8	18,562
SRI	2.6	4,219	3.6	16,935	3.4	21,153
Resources for the Future	2.0	3,400	2.9	14,600	2.7	18,000
Australian Mineral Economics Pty. Ltd.	1.6	2,884	3.2	15,739	2.9	18,622
MIDAS-II	1.9	3,199	N/A	N/A	N/A	N/A

N/A - Not available

2.1 Copper Price Forecasts

The real price of copper has trended upwards over the last 20 years. The average U.S. Producer price between 1957 and 1960 expressed in 1982 U.S. dollars was approximately 88¢ per pound. The average price between 1967 and 1970 was $1.10 per pound. The average price was somewhat lower in the period 1977 to 1980 at $1.04 per pound, however, there are indications that the prices of the late 1970's are inadequate to rationalize further expansion of copper mining capacity.

Mikesell notes the example of the Cuajone mine in southern Peru which first began full operation in 1977 following a $726 million capital expenditure. In order to fully recover this capital expenditure and earn a 15 percent return on investment after taxes, a 1977 copper price of 97¢ per pound would be required, given mill capacity and ore reserves. Also, capital investment in the Cuajone property was made in the period between 1969 and 1977. Equivalent investment in 1977 was estimated at $1.2 billion. At this capital cost, a 1977 price of $1.35 per pound would be required to earn a 15 percent return on investment. Even applying a conservative inflation factor indicates a necessary 1982 price in excess of $1.90 per pound. These estimates are especially impressive in light of the fact that the Cuajone mine has been rated one of the lowest cost mines in the world.

Another example cited by Mikesell is based on a U.S. Bureau of Mines study of a typical new open pit mine in Arizona. The results of the study indicated 1973 prices of 63¢ per pound would be required to provide a 12 percent discounted cash flow over a twenty year period. This equates to a 1982 price of approximately $1.40 per pound assuming costs have inflated at the same rate as GNP. Also, evidence indicates that mining costs have inflated considerably more rapidly than GNP since 1973.

Even a number of existing mines were probably in serious financial difficulty throughout the late 1970's. A study by CIPEC in November 1977 estimated that 14 percent of Western world capacity could not cover full "operating" costs at less than 70¢ per pound. This would translate into approximately $1.00 per pound in 1982 again assuming that operating costs inflated at the same rate as GNP. Clearly, a considerable number of producers had a very slim margin for debt repayment, other fixed charges and return to capital during the late 1970's.

In general, copper prices appear poised for a substantial upward movement. One major U.S. forecasting firm has projected prices of $1.75 per pound (1982 dollars) by 1990. A similarly optimistic scenario is projected by Sousa using the MIDAS II computer model. Sousa predicts copper prices of $1.66 per pound (1982 $) by 1990 and $2.32 per pound (1982 $) by the year 2000. Sousa's estimates do, however, incorporate 30 percent and 25 percent assumed real inflation in capital and operating costs respectively over the projection period. In the context of the present analysis this is excessive.

In Table 2, Sousa's analysis has been used to derive optimistic and pessimistic price scenarios. Sousa's estimates of low and high demand growth have been generally deflated to reflect negligible real cost inflation over the projection period.

TABLE 2
Copper Price Forecasts
(1982 U.S.¢/lb)

Year	Optimistic	Pessimistic
1985	135	120
1990	170	140
2000	220	150

3.0 Coal

The coal reserves in Northwest British Columbia are of anthracite variety. At the present time Canada does not produce or export coal of this type and as a result market information is relatively sparse. A market exists for anthracite in South Korea, Japan and Europe. Major uses include home heating and cooking where anthracite is formed into briquettes, some thermal power generation and some industrial applications such as in the ceramics and earthenware industry. In most markets, anthracite is a close substitute with bituminous coal. More heat and low impurity levels are highly valued.

Japanese imports originate primarily in mainland China, North Korea and Vietnam with nominal amount from the U.S., U.S.S.R., Australia and South Africa. Japanese imports of anthracite dropped below one million metric tons in 1981 for the first time in nine years. Imports to this point in 1982 are down a further 35 percent. The recent declines are largely due to the world recession, however, the Japanese market is not expected to grow rapidly. Japanese imports will likely recover to one million metric tons and remain stable thereafter.

In contrast, South Korea offers a growing market for potential Canadian exports. According to intelligence reports from the Canadian Embassy in Seoul, South Korean demand for anthracite should expand quite dramatically over the next few years. Fully 90 percent of single family homes in urban areas, and 100 percent of rural homes still use anthracite for both cooking and heating. Since South Korea must purchase all of its oil from abroad at world prices, and 70 percent of its electricity is still generated using oil, the main substitutes for anthracite in domestic use are relatively expensive. Household demand is projected to rise steadily in the near future. Demand growth will only weaken in the 1990's when South Korea's proposed nuclear program begins to stabilize the cost of electricity.

On the supply side, South Korean production of anthracite has generally stagnated since 1978. Domestic production is expected to rise very slowly until 1986 and then to decline as more easily recoverable reserves are depleted. The costs of substantially increasing domestic production appear to be prohibitive. Table 3 following outlines the projected supply and demand balance for South Korea until 1986. Necessary imports grow to 5 million metric tons. After this, import demand may increase further as domestic production declines.

TABLE 3
South Korean Anthracite Coal Supply/Demand Projections
(000 tonnes)

	1978	1980	1982	1983	1984	1985	1986
Demand	17,953	20,830	22,811	24,896	25,305	25,657	26,513
Local Production	17,307	18,139	19,700	20,300	20,800	21,200	21,500
Shortfall (Imports)	646	2,017	3,111	4,596	4,505	4,457	5,013

Less is known about the potential European market. However, some anthracite is used for thermal electric power generation and there are indications of a renewed demand for anthracite for residential heating. With oil prices at their present levels a general reversion to coal heating is possible.

3.1 Coal Price Projections

The variation in prices for anthracite coal is very wide. Prices currently range on the Japanese market from $159 U.S. per metric ton (CIF) for the highest grade Vietnamese anthracite to $79.50 U.S. per metric ton (CIF) for U.S.S.R. anthracite. Kittredge has shown that heat content, ash content, moisture content, sulphur content and volatile matter content are all influences on the final price of the commodity. Kittredge estimates, using an empirically derived reference equation, a 1982

market value of $89 U.S. per metric ton for Canadian semi-anthracite coal from British Columbia's North East coal fields. Insufficient information is available to generate an accurate current value for Groundhog coal from Northwest British Columbia. However, the consensus is that the quality of Groundhog coal is almost certainly better, and can be expected to command a higher price of perhaps $105 U.S. per metric ton.

A major influence on future anthracite prices is the limited supply potential from most of the current exporters. Anthracite coal mining has been a declining industry for over sixty years. For example, peak U.S. production in the range of 100 million tons was reached prior to 1920 and recent production has declined to approximately 5 million tons. Anthracite was basically driven from the market by constantly declining real oil and natural gas prices. As a result, the infrastructure and methods used in the industry are by and large archaic and high cost. For current producers to expand production to any extent will require major capital expenditures to modernize the production and delivery systems.

Table 4 following offers an optimistic and pessimistic scenario regarding future price of anthracite coal from Northwest British Columbia. Under an optimistic scenario, world demand will increase substantially requiring major investment in anthracite coal mining capacity. We also assume that the Groundhog deposits prove out as relatively high quality. As a result, the price of Groundhog coal advances from $100 U.S. (1982) per metric ton in 1985 to $150 U.S. (1982) per metric ton by the year 2000. Under the pessimistic scenario, the world market remains constrained and the Groundhog coal deposits prove out as relatively low quality. Under this scenario, prices remain at a low level of $85 U.S. (1982) per metric ton throughout the projection period.

TABLE 4

Anthracite Coal Price Projections
(1982 U.S. $ per metric ton)

Year	Optimistic	Pessimistic
1985	$100	$85
1990	$115	$85
2000	$150	$85

4.0 Molybdenum

Molybdenum is a relatively new metal in the sense that major use does not pre-date the twentieth century. The first substantial application dates from the First World War when a shortage of tungsten created a demand for alternative alloying elements in military hardware. Production was also boosted in the 1940's and 1950's by World War II and the Korean War respectively. Major consumption growth dates from the 1960's with world consumption of molybdenum increasing at an annual average rate of 4.2 percent since 1966. Average annual consumption growth in the 1970's increased to 6 percent per annum.

Corrosion resistance, high melting point, hardenability and ductile strength are the properties which create a demand for molybdenum. It is primarily used as an alloying element in steel. On a sectoral basis, transportation and machinery are now the major users with oil and gas, chemicals and electrical also large users.

High strength-low alloy steel (HSLA) accounts for the major application of molybdenum. Over 40 percent of molybdenum production is used in this way despite a molybdenum content by weight of less than 0.5 percent. HSLA is used in transportation equipment, industrial machinery, oil and gas pipelines and long span bridges. The use of molybdenum in stainless steel accounts for an additional 20 percent of current consumption. The transportation sector is a large user of this in automotive trim to protect from salts and moisture. The nuclear industry is also a growing user in pressure vessels and heat transfer systems.

Higher molybdenum content steel and pure metal is also used extensively in the machinery sector. Molybdenum has captured a good deal of the market in drills, taps, punches, dies and other tool applications and in high temperature engines.

Clearly, the consumption of molybdenum is highly correlated to the consumption of steel. However, the consumption of molybdenum increased at a more rapid rate than steel throughout the 1970's reflecting the expansion of the metal into new uses. In effect, molybdenum has been recently substituting for other alloying elements such as tungsten due to its superiority in certain applications and its relative price. Also, as energy prices have risen, the need for steels that combine lightness with strength has increased. Oil and gas pipelines have been stretching to more remote areas and demands for improved gasoline mileage have been growing.

Table 5 following, outlines the U.S. Bureau of Mines forecast of world molybdenum demand to the year 2000. The "probable" demand by their definition represents a distinct slowing from the high consumption growth rates of the 1970's. In spite of this, total projected consumption triples over 1977. Even the low end of the Bureau's forecast range represents a 250 percent increase over 1977.

TABLE 5
U.S. Bureau of Mines
World Molybdenum Demand Projections
(short tons)

		2000 Forecast Range		Probable		Probable Average Annual Growth Rate
	1977	Low	High	1985	2000	1977-2000
United States	30,675	75,000	100,000	46,500	85,000	4.5%
Rest of the World	77,500	200,000	260,000	121,000	230,000	4.8%
World Total	108,175	275,000	360,000	168,000	315,000	4.8%

4.1 Molybdenum Price Forecasts

The real price of molybdenum was relatively stable from the mid-1950's to the mid 1970's at between $3.60 and $4.40 U.S. per pound in 1982 dollars. The reason for this was the dominance in the market place of Climax Molybdenum (a division of AMAX). In 1978, this company still held close to a 40 percent share of world output. Climax basically set the market prices with all other major producers following their lead.

As the demand for molybdenum began to press against supply availability in the mid 1970's the traditional stability in the market began to break down. Industry inventories began falling steadily as Western world consumption exceeded production in every year between 1973 and 1978. By late 1978, shortages of molybdenum became serious and other molybdenum producers began to initiate price increases independent from Climax. In the third and fourth quarters of 1979, the lid blew off the market. The by-product price for molybdenum concentrate increased first to an average $17.50 U.S. per pound and then to an average $21.00 U.S. per pound. While Climax prices also increased substantially they remained well below other producers at $8.84 U.S. per pound throughout the last six months of 1979.

Since that time prices for molybdenum have slumped to more historical norms. Average molybdenum by-product prices for 1980 were $9.83 U.S. and for 1981 were $5.35 U.S. per pound. Second quarter 1982 prices bottomed at $3.64 U.S. per pound. Part of the reason for this has been the general downturn in the world economy. Another reason, however, has been the increase in world production encouraged by the boom prices of the late 1970's. Despite slumping markets which have seen a 20 percent reduction in consumption between 1979 and 1981, world production of molybdenum has increased by 6 percent. In contrast to the 1970's market supply now vastly exceed current demand and estimated inventories have grown dramatically. Stocks now exceed one year's total consumption.

Given this situation, the short term outlook for molybdenum prices is far from healthy. Prices will likely remain at their present depressed levels in real terms until 1985. Also, dramatic upward movement after this date is unlikely. A 1976 study by the U.S. Bureau of Mines indicates that economic reserves of molybdenum are relatively abundant in relation to projected demand. One indication of this is that 70 to 80 thousand tons of new capacity has been announced for the 1980's and some of this has already been commissioned. In particular, a potential development by U.S. Borax at Quartz Hill in the Alaska Panhandle is massive, representing about 20,000 tons of this capacity or about 25 percent of current world consumption. This project is presently scheduled to enter production in 1987.

For analytical purposes, optimistic and pessimistic price scenarios are presented in Table 6. In both scenarios, the price for molybdenum is shown as recovering to its historical average of $4.00 U.S. per pound (1982 $) by 1985. In the pessimistic scenario, prices increase marginally to $4.50 per pound by 1990 and remain at this level until the year 2000. In the optimistic scenario, prices increase to $5.00 per pound in 1990 and increase further to $6.00 per pound by the year 2000.

TABLE 6

Molybdenum Price Forecasts

(1982 US $/lb)

Year	Optimistic	Pessimistic
1985	4.00	4.00
1990	5.00	4.50
2000	6.00	4.50

5.0 Zinc

Consumption growth for zinc averaged a relatively high level of 4.6% per annum between 1960 and 1974. In the late 1970's, however, consumption growth slowed dramatically to an average 2% per annum. Although growth stayed above 4% in the centrally planned economies and in Asia, average growth was only 0.6% in Europe, and consumption actually declined in the United States.

Zinc is used for its corrosion resistance. In 1979 almost 40% of total demand was related to galvanized iron and steel in construction. Another major element of demand was for die casting of trim, grills, door-handles, etc. on automobiles. Zinc is also the main alloy used with copper in brass-making for plumbing and heating industries. Other miscellaneous uses of zinc include paint (as a safer substitute for lead) again to promote corrosion resistance and zinc oxide finds a variety of chemical and other industrial uses.

Zinc consumption growth is not expected to revert to the high rates experienced in the 1960's and early 1970's. However, consumption growth is expected to be somewhat higher than in the late 1970's. There is no satisfactory substitute for zinc in galvanizing iron and steel in major construction usage. Growth in this area should be healthy, particularly in less developed countries. Aluminum and magnesium are substitutes for zinc in die-casting and both of these materials have weight advantages. Some substitution is expected in this area. Non-metal uses of zinc are expected to witness the most substantial growth. The use of zinc and zinc oxide in paints, chemical applications and rubber products will lead to a doubling of current consumption in this area by the year 2000.

TABLE 7
World Zinc Demand Forecasts
(000 Metric tons)

a) U.S. Bureau of Mines

		2000				Probable Average Growth
	1978	Low Demand	High Demand	Probable 1990	Probable 2000	1978-2000
United States	1229	1200	2500	1400	1800	1.7%
Rest of the World	5550	6900	10500	7190	8800	2.1%
Total World	6779	7600	13000	8590	10600	2.1%

b) Mallenbaum

	1985	2000	Average Growth 1975-2000
United States	1600	2001	N/A
Rest of the World	6653	10021	3.1%
Total World	8253	12022	2.9%

Table 7 above outlines two world zinc demand forecasts. The U.S. Bureau of Mines projects an increase in consumption of between 12 and 92 percent by the year 2000. Mallenbaum's projections are close to the U.S. Bureau's high demand projections over the period. However, Mallenbaum's work pre-dates the slump in demand during the late 1970's. The U.S. Bureau's "probable" growth rate of 2.1% per annum may be more realistic.

5.1 Zinc Price Forecasts

The real price of zinc remained very stable for over one hundred years prior to the 1970's. However, over the last decade prices have moved dramatically upwards. In 1982 dollars, the average U.S. producer price for High Grade zinc between 1967 and 1970 was approximately 35 cents U.S. per pound. In the late 1970's, producer prices averaged approximately 45¢ U.S. per pound. In spite of this, economic reserves of zinc appear very sparse in relation to projected demand by the year 2000. A 1976 study by the U.S. Bureau of Mines estimated that reserves represented only 80 percent of probable cumulative demand to the year 2000.

Virtually all analysts agree that the real price of zinc will increase quite dramatically over the next two decades. The general consensus is that zinc prices will rise to between 55¢ and 60¢ U.S. per pound (1982$) by 1985 or even earlier. By 1990, prices of 70¢ per pound or above could be realized.

Table 8 following outlines pessimistic and optimistic price scenarios. Under the pessimistic scenario prices recover from their current cyclical low to 45¢ per pound by 1985. Prices reach 55¢ per pound in 1990 and increase to 60¢ per pound by the year 2000. Under the optimistic scenario prices reach 60¢ per pound in 1985, increase to 70¢ per pound by 1990 and increase further to 80¢ per pound by the year 2000.

TABLE 8
Zinc Price Forecast
(1982 U.S. ¢ per pound)

	Optimistic	Pessimistic
1985	60	45
1990	70	55
2000	80	60

6.0 Asbestos

Asbestos is used in more than 3,000 different ways and particular uses are identified with specific grades of the asbestos fibre produced. The primary feature is fibre length, however, within particular length categories there is further wide sub-division of grades. For example, the Cassiar mine in Northwestern B.C. offers four different length grades but pricing differentiates ten different categories of product. Prices in January 1980 ranged from $2000 to $375 Canadian per short ton with a general premium for longer length fibres.

The longest grades of asbestos fibre (grades 1, 2 and 3) are used primarily in textiles (such as fire proof clothing and theatre curtains), different types of packing and electrical insulation materials. Grades 4, 5 and 6 are used largely in cement products as a binding material. The longer fibres (#4) are used in asbestos cement pipe subject to high pressure such as in municipal waterworks and irrigation systems. The shorter fibres (#5 and #6) are used in low pressure uses such as asbestos cement sheet and friction products such as brake and clutch linings. The shortest fibres (#7 and #8) are used primarily in flooring and roofing products, insulation and fire resistant coatings and compounds.

In total, over 75% of asbestos demand is related to the construction industry in one form or another. Asbestos consumption is thus highly dependent on future construction activity. However, there are a number of other influences which could affect future markets. There is considerable controversy regarding the health aspect of asbestos usage. Scientific consensus holds that there is a relationship between exposure to asbestos dust and cancer, but there are a number of conflicting reports regarding threshold limits of exposure, etc. In any event, the result has been considerable effort devoted to developing substitute products.

To this date there has been a lack of success in producing a material with properties equivalent to asbestos. The most successful has been a glass based fibre called Cemfil, but this only rates about 60% percent of the tensile strength of asbestos. Also, it has inferior drainage properties and is comparatively expensive. However, continued research efforts may bear fruit and this could have dire consequences for future asbestos consumption.

Table 9 following outlines the U.S. Bureau of Mines world asbestos demand projections to the year 2000. Surprisingly, even under the low demand forecast, world consumption of asbestos fibre doubles by the year 2000. The Bureau rationalizes that rapid growth in construction activity and fewer environmental and health concerns in less developed countries will more than offset a stagnating U.S. market. Energy, Mines and Resources Canada is considerably less optimistic. Total projected world consumption according to EMR will be 8.6 million metric tons by the year 2000. This is approximately half the projected growth rate of the U.S. Bureau of Mines probable forecast, and well below the Bureau's low forecast.

TABLE 9
World Asbestos Demand Forecast
(000 metric tons)

		2000		Probable		Probable Average Annual Growth
	1978	Low	High	1990	2000	(1978-2000)
United States	619	397	920	620	620	0%
Rest of the World	4135	9806	14420	7720	11987	4.5%
World Total	5154	10203	15340	8340	12607	4.1%

6.1 Asbestos Price Forecasts

Average real prices for asbestos remained relatively stable until the 1960's. Prices declined marginally from approximately $310 (1982) per metric ton in the late 1950's to approximately $280 (1982) per metric ton in the late 1960's. Prices bottomed in the mid 1970's at below $250 (1982) per metric ton under the combined influence of the oil based recession and environmental concerns. Prices then rebounded substantially and finished the decade at approximately $350 (1982) per metric ton.

There are two reasons to believe that asbestos prices will show continued upward movement in the future. First, U.S. Bureau of Mines studies in both 1976 and 1978 show that estimated economic reserves of asbestos are extremely sparse in relation to projected cumulative demand to the year 2000. Real prices should rise to bring marginal resources into production. Second, increasingly stringent environmental and safety regulations on asbestos mining will raise the costs of extracting and processing the resource. Long run prices must rise to compensate for this. At the same time, Canadian fibre is relatively dust free and thus Canadian producers will be less affected by rising costs.

Overall, the prospects for asbestos prices are good assuming that no environmentally superior substitute is found. Real prices could increase quite substantially over the next two decades. On the other hand, a successful substitute for asbestos could effectively destroy the market. The experience of the late 1960's and early 1970's indicates that real prices can fall substantially under the pressure of environmental concerns and declining demand. Under a pessimistic scenario, prices would at best remain constant over the next two decades.

A specific price scenario for asbestos from Northwest British Columbia poses certain problems as the market price is more dependant on the quality of the fibre than the trend in the general market. It is known that the average quality of Letai

asbestos, the major potential asbestos mine in the Northwest, is considerably lower than at the presently operating mine at Cassiar. However, the specific quality of the potential product is still open to some question. The average 1981 price for Cassiar products was approximately Can $900 per tonne. On this basis, the pessimistic scenario outlined in Table 10 fixes the price of Letain asbestos at 50 percent of the Cassiar price or Can $450 per tonne, throughout the projection period. On an optimistic basis, the quality of Letain asbestos is assumed considerably higher and the price increases throughout the projection period.

TABLE 10
Asbestos Price Forecast
(1982 C$ per tonne)

	Optimistic	Pessimistic
1985	600	450
1990	700	450
2000	800	450

7.0 Silver

Demand for silver for industrial and new coinage has vastly exceeded new mine production for a number of years. Non-communist world demand in both 1980 and 1981 was approximately 11,000 metric tons while new mine production was only 8,000 metric tons. The shortfall in production was made up by substantial recycling operations and by lowering the silver content of coinage. Net use of silver in coinage actually decreased by 1285 metric tons in 1980 and by 186 tons in 1981.

The major end use for silver is in silver nitrate for photographic developing. In 1980, this accounted for 40 percent of total consumption. Use of silver as contacts and conductors in both the electrical and electronic industries accounted for an additional 27 percent of total demand. Surprisingly, the more visible uses of silver in jewelry, sterling ware, medallions and commemorative coins only accounted for 16 percent of total demand in 1980.

Photography will continue to be the major source of demand growth in the future. Research has not discovered a suitable substitute for silver nitrate in photographic processing. In other industrial uses there are ample substitutes for silver and demand in this area is unlikely to grow rapidly. Silver consumption for decorative and commemorative purposes is likely to grow at least as rapidly as world population especially in light of recent price trends with gold, the major alternative material. On the other hand consumption of silver in coinage is likely to decline rapidly. By the year 2000 silver could be completely phased out of general circulation coinage.

Table 11 following outlines the U.S. Bureau of Mines forecast of silver demand to the year 2000.

TABLE 11
U.S. Bureau of Mines
World Silver Demand Projections
(metric tons)

	1976	2000 Forecast Range		Probable 1985	Probable 2000	Probable Average Annual Growth 1976-2000
United States	4878	6806	14320	6522	8791	2.5%
Rest of the World	8904	11343	18432	11059	15029	2.2%
Total World	13782	18149	32752	17581	23820	2.3%

Under the Bureau's low range forecast, consumption only increases by 32 percent over 1976. This largely reflects the possibility of a substitute for silver nitrate in photographic processing. Under the high range forecast, consumption triples by the year 2000. The probable forecast shades towards the low forecast representing a relative modest growth rate in consumption of 2.3 percent per annum.

7.1 Silver Price Forecast

Silver prices have moved consistently upwards for the last two decades. The average real price between 1957 and 1960 was approximately $2.78 U.S. (1982) per troy ounce.[1] In the late 1960's average prices had advanced to 4.52 U.S. (1982) per troy ounce. In the late 1970's, silver entered the speculative fold with gold and violent fluctuations in price have resulted. In January 1980, the silver price hit $48.00 U.S. per troy ounce and prices later in the year ranged down to $11.00 U.S. per troy ounce. In 1981, prices ranged between $8.00 and $16.00 U.S. per troy ounce. In 1982, prices have been much more stable at relatively low levels of between $7.00 and $10.00 U.S. per troy ounce.

Predicting prices for speculative commodities is particularly difficult. The recent excess of demand over new mine production points to further upward movement in long term prices. Reinforcing this belief, is the fact that the potential supply from debasing coinage is constantly decreasing and will dry up quite rapidly. Also, evidence over the last two years indicates that substantial other scrap supplies will not re-appear without substantial upward movement in prices. On the other hand, many governments hold large stocks of silver bullion. Surprisingly, governments have been large net hoarders of silver over the last two years. Eventual release of these stock piles could depress the market for a considerable length of time. A final element in the equation is a general insensitivity of silver supply to silver prices. Fully 80 percent of new silver production comes as a by-product of other base metal production (primarily copper, lead and zinc). By-product production may act to either counteract or reinforce silver price trends depending upon events in other metal markets.

Table 12 following offers an optimistic and pessimistic scenario regarding future silver prices. Given historical trends, even pessimistically it seems unlikely that the real price of silver will decline. It is assumed tht prices will stabilize at $10.00 U.S. per troy ounce by 1985 and will remain at that level until the year 2000. Under the optimistic scenario, we assume a dramatic upward movement in prices. Prices advance to $15.00 U.S. per troy ounce by 1990 and advance further to $25.00 U.S. per troy ounce by the year 2000.

TABLE 12
Silver Price Forecasts
(1982 U.S. $/troy ounce)

Year	Optimistic	Pessismistic
1985	10.00	10.00
1990	15.00	10.00
2000	25.00	10.00

8.0 Gold

The major use of gold, and in many countries the only use of gold, in fabricated products is in jewelry. This usually accounts for between 70 and 80 percent of total fabricated consumption in the non-communist world. A small amount (about 7 or 8 percent) is used in dentistry in inlays, crowns and bridges, etc. Finally, primarily in the more developed countries, some gold is used in specialized electronics applications as a conductor and in brazing alloys used in the aerospace industry.

The prospects for consumption growth in all of these areas is highly uncertain. Non-communist world consumption in jewelry declined from 32 million troy ounces in 1977 to 19 million troy ounces in 1981. Jewelry demand has shown itself to be responsive to price changes. Over the same period, non-communist world consumption in dentistry and industrial uses remained relatively stable at approximately 7 million troy ounces. However, there are definite trends here to more efficiency in usage.

Table 13 following outlines the U.S. Bureau of Mines forecast of world demand for fabricated gold. Under the low forecast range, the Bureau estimates that fabricated demand will grow by a relatively modest 22 percent between 1976 and the year 2000. Under the high forecast range, the Bureau estimates an 85 percent increase over this period. The probable forecast shades towards the low forecast with a 36 percent increase in total fabricated consumption. This represents a modest average increase in consumption of 1.3 percent per annum.

TABLE 13

U.S. Bureau of Mines

World Demand for Fabricated Gold Projections

(000 troy ounces)

		Forecast	Range	Probable		Probable Average
	1976	Low	High	1985	2000	Growth
United States	4,648	6,200	15,200	5,900	8,500	2.5%
Rest of the World	42,609	51,600	72,200	47,000	55,600	1.1%
World Total	47,257	57,800	87,400	52,900	64,100	1.3%

It should be emphasized that the Bureau's forecasts pre-date the high gold prices of the late 1970's and early 1980's. Consequently, the forecasts probably overestimate demand to some considerable extent. However, they do give an indication of the relative strength of underlying market forces.

8.1 Gold Price Forecasts

Western world consumption of gold in fabricated products exceeded production of new gold throughout the 1970's. In 1981, after substantial price increases, fabricated demand and production were roughly in balance. In spite of increased prices, the production of new gold has remained relatively stable and the prospects for increased supplies are not rated as good. Under normal circumstances this would point to further upward movement in real prices over time.

However, gold is the penultimate speculative commodity. The history of gold as a store of value pre-dates written history and uncertainty regarding the future has consistently re-fuelled demand for the metal. Private and public hoarding and dis-hoarding of gold is the primary determinant of price in both the short and long run.

The real price of gold decreased throughout the 1950's and 1960's due to the U.S. government intervention to hold an official current price of $35.00 per troy ounce. In 1971, the United States left the gold standard and in 1974 restrictions on the private ownership of gold in the United States were removed. Since that time gold prices have advanced substantially, reaching an average of $612 U.S. per troy ounce in 1980. In 1981, prices declined to an average $460 per troy ounce and in 1982 have fallen further to a $300 to $400 U.S. price range.

Three major elements have interacted to create the wildly fluctuating market of recent years. Private speculative consumption of gold increased from 13 million troy ounces in 1977 to approximately 23 million troy ounces in 1979. Throughout this period price increases were constrained due to substantial sales by Western governments and heavy exports from the Communist bloc. In 1980, Western governments dramatically reversed policy and began to substantially increase gold reserves. At the same time, Communist bloc exports dropped to negligible levels. In 1981 and 1982, private speculative demand has cooled considerably due to the record rates of return on alternative investments and the lowering inflation rate. Also, communist exports have returned to more normal levels. While Western governments are continuing to be net purchasers of gold, this has been unable to stem the retreat in prices from their 1980 peaks.

The major element of uncertainty regarding the future trend in gold prices lies in the large stocks of gold held both privately and by governments. It is estimated that approximately one half of the world's gold mined to date is held in government vaults. This is a potential supply of 1.3 billion troy ounces. Another 500 million troy ounces are held in private hoardes. The size of these stocks are such that normal supply and demand relationships need not, and do not, apply to gold pricing.

Table 14 following offers an optimsitic and pessimistic scenario regarding future gold prices. Given the arbitrary nature of the exercise, we pessimistically assume a fixed price of $250 U.S. (1982) per troy ounce throughout the projection period. Optimistically, we assume prices rise to $750 U.S. (1982) per troy ounce by 1985 and stay at this level throughout the projection period.

TABLE 14
Gold Price Projections
(1982 $ per troy ounce)

	Optimistic	Pessimistic
1985	750	250
1990	750	250
2000	750	250

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